This Page Is Inserted by IFW Operations
and is not a part of the Official Record

# BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

## IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.**

# PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

## PCT

### NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

| | |
|---|---|
| **Date of mailing** (day/month/year)<br>18 June 2001 (18.06.01) | |
| **International application No.**<br>PCT/IL00/00528 | **Applicant's or agent's file reference**<br>P-2684-PC |
| **International filing date** (day/month/year)<br>04 September 2000 (04.09.00) | **Priority date** (day/month/year)<br>09 September 1999 (09.09.99) |
| **Applicant**<br>KLIATZKIN, Vladimir | |

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

02 April 2001 (02.04.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

| | |
|---|---|
| **The International Bureau of WIPO**<br>**34, chemin des Colombettes**<br>**1211 Geneva 20, Switzerland** | Authorized officer<br>Claudio Borton |
| Facsimile No.: (41-22) 740.14.35 | Telephone No.: (41-22) 338.83.38 |

# PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

## PCT

NOTIFICATION CONCERNING
AMENDMENTS OF THE CLAIMS

(PCT Rule 62 and
Administrative Instructions, Section 417)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as International Preliminary Examining Authority

| Date of mailing (day/month/year) | |
|---|---|
| 18 June 2001 (18.06.01) | |
| International application No. | International filing date (day/month/year) |
| PCT/IL00/00528 | 04 September 2000 (04.09.00) |
| Applicant | |
| UNIBAT LTD. et al | |

The International Bureau hereby informs the International Preliminary Examining Authority that no amendments under Article 19 have been received by the International Bureau (Administrative Instructions, Section 417).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Claudio Borton

Telephone No. (41-22) 338.83.38

# PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

## PCT

**NOTIFICATION OF RECEIPT OF RECORD COPY**

(PCT Rule 24.2(a))

To:

COHEN-ZEDEK, Nachman
Eitan, Pearl, Latzer & Cohen-Zedek
Gav Yam Center 2
Shenkar Street 7
46725 Herzlia
ISRAËL

| **Date of mailing** (day/month/year) | **IMPORTANT NOTIFICATION** |
|---|---|
| 18 October 2000 (18.10.00) | |
| **Applicant's or agent's file reference** | **International application No.** |
| P-2684-PC | PCT/IL00/00528 |

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

UNIBAT LTD. (for all designated States except US)
KLIATZKIN, Vladimir (for US)

| | | |
|---|---|---|
| International filing date | : | 04 September 2000 (04.09.00) |
| Priority date(s) claimed | : | 09 September 1999 (09.09.99) |
| Date of receipt of the record copy by the International Bureau | : | 20 September 2000 (20.09.00) |
| List of designated Offices | : | |

AP :GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZW
EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
National :AE,AG,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,BZ,CA,CH,CN,CR,CU,CZ,DE,DK,DM,DZ,EE, ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA, MD,MG,MK,MN,MW,MX,MZ,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,US, UZ,VN,YU,ZA,ZW

**ATTENTION**

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

**In addition, the applicant's attention is drawn to the information contained in the Annex**, relating to:

- [X] time limits for entry into the national phase
- [ ] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

**The International Bureau of WIPO**
**34, chemin des Colombettes**
**1211 Geneva 20, Switzerland**

Facsimile No. (41-22) 740.14.35

Authorized officer:
David Lopez-Ramirez

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

# PCT

REC'D 16 APR 2002
PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

**(PCT Article 36 and Rule 70)**

8

| Applicant's or agent's file reference<br>P-2684-PC | **FOR FURTHER ACTION** | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) |
|---|---|---|
| International application No.<br>PCT/IL00/00528 | International filing date *(day/month/year)*<br>04 September 2000 (04.09.2000) | Priority date *(day/month/year)*<br>09 September 1999 (09.09.1999) |
| International Patent Classification (IPC) or national classification and IPC<br>IPC(7): H01 2/02, 8/04 and US Cl.: 429/129, 131, 132, 136, 139 | | |
| Applicant<br>UNIBAT, LTD | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of report with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

| Date of submission of the demand | Date of completion of this report |
|---|---|
| 02 April 2001 (02.04.2001) | 18 March 2002 (18.03.2002) |
| Name and mailing address of the IPEA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. (703)305-3230 | Authorized officer<br>Carol Chaney<br>Telephone No. 703-308-0661 |

INTERNATIONAL PRELIMIN[redacted]EXAMINATION REPORT

International ap[redacted]tion No.
PCT/IL00/005[redacted]

## I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed.

☒ the description:
pages 1-15 as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____.

☒ the claims:
pages 16-20 , as originally filed
pages NONE , as amended (together with any statement) under Article 19
pages NONE , filed with the demand
pages NONE , filed with the letter of _____.

☒ the drawings:
pages 1-4 , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____.

☐ the sequence listing part of the description:
pages NONE , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination(under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages NONE

☐ the claims, Nos. NONE

☐ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*
*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMIN XAMINATION REPORT

International application No.
PCT/IL00/005[redacted]

**V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. STATEMENT

| | | | |
|---|---|---|---|
| Novelty (N) | Claims | 3, 5-9, 11-19, 21, 23-24, 26 | YES |
| | Claims | 1, 2, 4, 10, 20, 22, 25 | NO |
| Inventive Step (IS) | Claims | 3, 5-9, 11-19, 21, 23-24, 26 | YES |
| | Claims | 1, 2, 4, 10, 20, 22, 25 | NO |
| Industrial Applicability (IA) | Claims | 1-26 | YES |
| | Claims | NONE | NO |

2. CITATIONS AND EXPLANATIONS

Claims 1, 2, 10, 22, and 25 lack novelty under PCT Article 33(2) as being anticipated by Honda et al., US Patent 5,580,676.

Honda et al. disclose batteries which include anodes and cathodes individually enveloped by microporous separator material. (Fig. 20.) The electrode active materials are in granular form. (col. 3 line 63-col. 4, line 6.)

Claims 1, 2, 4, 10, 20 and 22 lack novelty under PCT Article 33(2) as being anticipated by Erez et al., US Patent 5,480,742). Erez et al. disclose batteries which include anodes and cathodes surrounded (enveloped) by a separator material. (col. 3, lines 3-24 and Figs. 1-2, reference numerals 12, 18, and 30.)
The electrodes are enveloped by flexible materials. (col. 4, lines 10-14 and col. 3, lines 21-24.)

Claims 3, 5-9, 11-19, 21, 23, 24, and 26 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest rechargeable battery cells having particulate active materials of the constructions claimed by the applicants. The prior art does not disclose particulate catalytic fuel cell structures as claimed by the applicants.

---------- NEW CITATIONS ----------

## VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

The wording of claim 3 is unclear. In the phrase "where the electrode fabric is woven and pleated active materials is a flexible electrically conducting fabric..." it is unclear if "pleated refers to the electrode fabric or the active materials.

In claimed 25, the examiner suggests the phrase "said electrode executed by sintering, ...." be replaced by "said electrode *produced* by sintering, ...."

## VIII. Certain bservations on the international application

The following observations on the clarity of the claims, description, and drawings or on the questions whether the claims are fully supported by the description, are made:

Claims 10, 11, 12, 14, 15, and 16 are objected to under PCT Rule 66.2(a)(v) as lacking clarity under PCT Article 6 because claims 10-12, 14, and 15 are indefinite for the following reason(s): In claim 10, the terms "high mechanical strength" and "high strength" are relative terms which are not defined. In claim 11, the modification intended for "A modified cell of claim1..." is not clear. In claim 12, the term "high surface area" is a relative term which is not defined. In claims 14-16, the antecedent basis for "the bulk..." is not clear. In claim 14 the terms "medium pressure" and "low pressure" are relative terms which are not defined.

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL00/00528

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :H01M 2/02, 8/04
US CL : 429/129, 131, 132, 136, 139
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 429/129, 131, 132, 136, 139

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 5,580,676 A (HONDA et al.) 03 December 1996, Fig. 20; col. 2, lines 28-35; col. 4, lines 4-6. | 1, 2, 6, 10, 22, 25 |
| X | US 5,480,742 A (EREZ et al.) 02 January 1996, Fig. 4 and col. 3, lines 31-42. | 1, 2, 4, 10, 22 |
| X | US 4,160,068 A (KUMMER) 03 July 1979, col. 3, lines 4-24; column 4, lines 10-14; Figs. 1 and 2. | 1, 2, 4, 10, 22 |
| A | US 829,643 A (FORD) 28 August 1906, the entire document. | 1-26 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 14 JANUARY 2001 | 05 FEB 2001 |
| Name and mailing address of the ISA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. (703) 305-3230 | Authorized officer<br>CAROL CHANEY<br>Telephone No. (703) 308-0651 |

Form PCT/ISA/210 (second sheet) (July 1998) ★

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number
WO 01/18890 A1

(51) International Patent Classification[7]: H01M 2/02, 8/04

(21) International Application Number: PCT/IL00/00528

(22) International Filing Date:
4 September 2000 (04.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
131842 9 September 1999 (09.09.1999) IL

(71) Applicant *(for all designated States except US)*: UNIBAT LTD. [IL/IL]; Yozmot Haemek, P.O. Box 73, 10550 Migdal Ha'emek (IL).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: KLIATZKIN, Vladimir [IL/IL]; Alon Street 18, 29550 Kiryat Yam (IL).

(74) Agent: COHEN-ZEDEK, Nachman; Eitan, Pearl, Latzer & Cohen-Zedek, Gav Yam Center 2, Shenkar Street 7, 46725 Herzlia (IL).

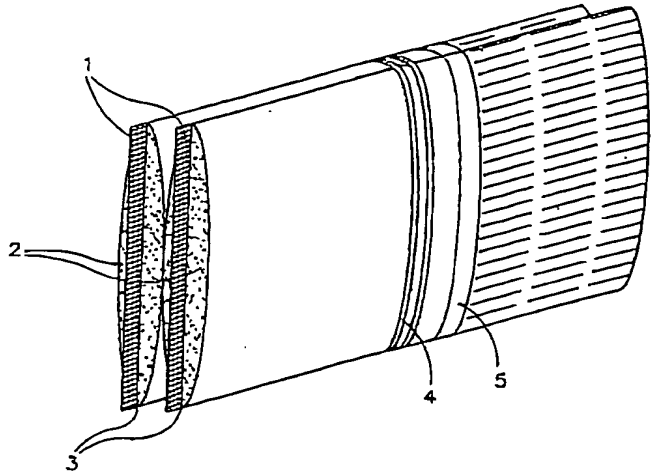
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

*[Continued on next page]*

(54) Title: CHARGEABLE ELECTROCHEMICAL CELL




(57) Abstract: An electrochemical cell for batteries comprising one or more pairs of electrodes (6). The first electrode is comprised of a flexible electrically insulating and ion conducting envelope (5) which contains a flexible conducting substrate (1). The flexible conductor (1) can be made of a conductive material in the form of fabric or grid, inserted into an active material in granular or powder form (2). The second electrode is also a flexible electrically insulating envelope (5) containing an electrical conductor (1) inserted into a layer of an electrochemically complementary active material. The cell also contains a means for applying pressure (4) to the assembly of electrodes, the membrane separator, and the counterelectrodes so as to maintain contact between the active material particles and the conductor. The assembly also contains a suitable electrolyte; electrode connections are provided from each of the envelopes.

WO 01/18890 A1

— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# Chargeable Electrochemical Cell

## FIELD OF THE INVENTION

This invention relates to a flexible design for accumulators, fuel cells and electrolyzers based on super light and super strong conductive and insulative materials in the form of special woven fabrics. This design can withstand very heavy overloads (property weight) at high accelerations of up to 50,000 g. As a result, there is an increase in kinetic uses of such accumulators. The same is true for insulation and cell materials which can be provided in a monolithic design. This kind of design can withstand accelerations of up to 55,000 g, i.e., known products including artillery shells. The large decrease (10-50 times) in distance between electrodes in lead-acid accumulators with the resulting decrease in internal resistance of the accumulator (principal part of internal accumulator resistance) creates an element with high electrical efficiency. The active material used permits realization of deep charge-discharge cycles – twice that of accumulators with semi-rigid electrodes- and realized capacity of accumulator at multicycle work. A specific electrode material layout permits using pairs of electrode materials with dendrite problems for multicycle battery. The invention is suitable for lead-acid or silver-zinc accumulators, fuel cells, and electrolyzers, where weight and cost are important factors.

## BACKGROUND OF THE INVENTION

The problem of the high specific weight of accumulators, fuel cells and electrolyzers arises from the use of heavy metal electrodes, such as lead, silver, zinc, platinum, etc. These metals have very high densities and low mechanical strengths. Discharge depth is limited by electrode strength since active materials also have a structural function in electrodes.

These metals also have high active surface areas. A specific surface area of special electrodes such as porous electrodes or slurry or powder electrodes, is advantageous and may be used with or without a catalytic plate.

Some electrode pairs, such as zinc - silver, also have dendrite problems. As a result, dendrite induced short circuits limit the number of cycles during the life of a rechargeable battery.

An object of this invention is to decrease the weight and increase the strength of accumulator, fuel cell and electrolyzer electrodes. A design using carbon paper is described in U.S. Patent 4,894,355 which proposes to decrease the active surface area by cutting the ends of the fibers which consist of a carbon paper/polytetraflouroethylene composition. In this case, the main load of design takes carbon carrier material - paper, and conductivity parameters, determines thickness and span of electrode.

## SUMMARY OF THE INVENTION

One object of this invention is to combine in one unit conductivity or insulation parameters with a high strength/low weight ratio. Active and/or catalytic materials may be used in plate (catalytic fuel cell or electrolyser) or in friable form (accumulator). Friable materials permit a better use of the chemically active material without weakening the electrode's structure. The efficiency of the electrodes is increased as a result of enhanced intergranular contact induced by an external or internal spring or spring-like element and/or by the battery's outer casing. The invention unifies these parameters and as a result there is a decrease in weight per discharged energy.

According to the invention, the battery cell comprises an external or internal flexible envelope or flat layer in which a flat, electrically conductive, flexible wire or fabric grid is embedded in a matrix of granular or powder particles of an active material. Another envelope is also present containing an electrically conducting wire or fabric grid on which grains or particles of a complementary active metal or compound are positioned. The envelopes are separated by an insulating membrane which is permeable to the ions of a suitable electrolyte. There are conductive leads from each of the battery's cells. There is also a flexible mechanical spring or electrolyte swelling element that supplies the required pressure to counteract the electrode's volume changes resulting from the chemical reaction in the cell.

The active material can be placed in a membrane bag or between sheets. The grains of active material can be fixed in position as distinct units by welding the cover.

The present invention provides a means for applying pressure to the external surface of the assembled cell, ensuring close contact between the granular or powder particles and between the particles and the electrode during charging and discharging. This contact is maintained despite significant volume changes of the active material during the reaction.

Various pairs of metals or compounds can be used, such as Ag/Zn, Pb/PbO, etc.

The electrodes can be fabricated in the form of lengthy ribbons which are then rolled into a spiral configuration. In such a design, it is advantageous to provide a spring or spring-like means to apply pressure to the external surface of the electrodes and to fabricate the cells in cylindrical form.

The spring or spring-like element may be an entirely separate element included in the battery or associated with a swelling separator. Alternatively, the flexibility of the battery cell's walls can function as the spring element. A separate spring element is best suited for flat batteries where cell wall height is limited. The side walls of the cell are best suited to serve as the spring element when the cell has a cubic, or at least rectangular, shape. Flexible outer cylindrical containers can function as the spring element for cells with helical electrodes.

The powder or grains of the active material are preferably in the 5 to 10 micron range, although other sizes can be used.

The sheet grids may be made from expanded metals, such as silver (for Ag-Zn element). These are manufactured from expanded metal foil relevant to the active material of the cathode or anode. Conductive fabric thickness is generally about 10 μ to 500 μ, with a preferable thickness being about 100 μ. The fabric can be woven from carbon fibers. Conductive materials may be coated with suitable metals, the exact metal depending on the nature of the electrochemical couple in the cell and the environment in which the cell operates.

For multicell versions, the conductive thread may also be used in combination with non-conductive fibers. In such conductive fabrics, a plurality of parallel carbon fibers interwoven with fibers of Kevlar, nylon, polyester, etc. can be used. The configuration may be one in which each carbon fiber constitutes an electrode. It is clear that the carbon fibers must be connected and a conductor lead provided for the current output.

A modification of the invention based on the same concept comprises fuel cells in which each membrane bag contains catalyst particles preferably attached to a suitable support. The catalyst may be in the form of ceramic particles coated with an active material, such as Ni, Pt or Cd. A suitable acid can serve as a catalyst in the fuel cell with oxygen and hydrogen reacting to form water and produce electric current. Suitable electrode connections are provided for current uptake. In the case of fuel cells, no external pressure on the cell is required. A catalyst may be directly plated on the carbon fibers increasing the active surface area.

Due to the thin elements of the electrochemical cells, the weight to power output ratio is improved. Since the main elements of the cells are a conductive fabric, granular active material, suitable membranes and an electrolyte, the cells can withstand extreme accelerations and decelerations without detrimental effect on cell performance.

A high energy, high speed chargeable battery cell can be produced when provided in a helical configuration.

According to this invention, electrodes, connection elements and cell walls are made from high-strength, conductive or insulative fibers/fabrics, catalyst, and active material in plate or friable form or the like. Carbon fibers may be used as the conductive part of electrodes while for the insulative parts, nylon, polyester, Kevlar or glass fibers can be used. The exact choice of insulative material depends on the electrolyte chosen.

Different designs can be used depending on the electrochemical principles. Parts should be designed to obtain stable electrical contact, resulting in conductivity in friable forms of the active material. Similarly, there should be adequate contact between the active material and the current input-output elements.

Suitable designs can include:

1. Electrodes, insulation elements, spring and outer cell casing made from separate parts and assembled into a single unit.

2. Electrodes and insulation elements in one unit. One piece of fabric woven in accordance with the need for the combination of conductivity and insulation or conductivity, insulation and active materials.

Different electrolytic principles of accumulator design may be realized using the first design.

Determination of some of the parameters suggests the following design specifications: a fiber thickness of 10 μ, a fabric thickness of 0.05, a specific area for the electrode of 31.5 $cm^2$ per $cm^2$ of electrode geometry area. This is without any special surface treatment to increase the microsurface.

The active area per unit weight in this case is 1875 $cm^2/g$ about 1100 times greater than a solid surface.

Additional specifications include conductivity cross-section per span distance, 0.0157 $cm^2/cm$, electrical resistance, 0.4 - 0.5 $ohm*mm^2$, and a permissible stress of 50 $kg/mm^2$ given a fabric density of 168 $g/m^2$ i.e. a maximum destroying length of 30 km. In comparison, lead has a value of 0.122 km, zinc 0.63 km and copper 2.263 km. Therefore, a coated graphite fiber electrode can withstand acceleration 15 times greater than a copper electrode and 300 times greater than a lead electrode for electrodes of equal lengths.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a sectional view of the configuration of an accumulator of the Zn -Air or Zn- Ag type with anodes of the Zn – ZnO, Zn – AgO or Ag - ZnO slurry type

Figure 2 is a sectional view of the design of a Zn-Air accumulator cell or one with Zn - Ag pairs with anodes of the Zn – ZnO, Zn – AgO or Ag - ZnO slurry type

Figure 3 is a sectional view of a spiral design for an electrode couple.

Figure 4 illustrates a parallel or serial connection between cells.

Figure 5 illustrates a multicell, one-piece design of a special fabric.

Figure 6 illustrates multi-electrodes and multicells made from one piece of special fabric.

## DETAILED DESCRIPTION OF THE PRESENT INVENTION

Reference is now made to Fig. 1. Figure 1 is a sectional view of an example of a unit cell of fabric with central coaxially displaced conductive fabric elements.

Electrode conductive element 1 (cathode or anode) is a woven carbon fiber fabric. In this case, the fibers do not need special treatment to increase their microsurface.

Electrode housing 6 has a flat piece of conductive fabric 1 inserted into electrical insulation bag 5 filled with a zinc, lead or silver oxide slurry 2 on both sides of conductive element 1.

The electrode bag 6 and both layers of slurry 2 are pressed together by a spring and intake are in separate insulation chamber 5 made from electrolyte permeable insulating fabrics which represents an accumulator element.

Reference is now made to Fig. 2. Figure 2 is a sectional view of a design of a unit cell of fabric. Electrode conductor 1 (cathode or anode) is woven from carbon fibers. Again, the fibers do not require special treatment to increase their surface area.

Electrode conductor 1 is made from a zinc, lead or silver oxide slurry 2.

Electrode bag 1 can be provided with lattice or diagonal seams 7 to prevent agglomeration of the slurry powder into a single piece. This helps to ensure an adequate powder distribution on the electrode surface. The electrode bag and both intakes are in separate insulation chambers 3 made of electrolyte permeable insulating fabrics.

The insulation chambers may be changed and divided into pieces of fabrics, which may be sewn to form an electrode bag from the sides of a pair of electrodes. The sewing threads may be made of insulating material.

A couple of these insulated electrodes (cathode and anode) have one difference: the consistency of slurry 2. In an accumulator design, the electrode pair or set of electrode pairs may be held under pressure by spring elements 8 of a different form. This saves the pressure needed for electrical contact between slurry and conductive fabric and between separate slurry nucleus (about 0.5 $kg/cm^2$). However, this pressure supply needs structural integrity.

The electrode couple is located in a common shell 4 and constitutes a single cell. Shell 4 may be produced from flexible or rigid plastic materials like polyethylene, polypropylene, polyurethane or PVC. This material may be reinforced with glass, polyester, Kevlar, etc. fibers. The connection of all elements into a single unit may be effected by heat welding at 5. The free electrode ends 6 may be used for the electrical connection of the cell.

The shape of the electrode and its position in a battery cell may vary. Among the various alternatives which can be used in a plate electrode with trim placing or a circular electrode in a coaxial structure. Electrolyte may be stored permanently in shell 4 or supplied periodically by special welding tubes.

Figure 3 is a sectional view of a spiral design for electrodes. A pair of flexible electrodes 1 and 2 of the form shown in Figs. 1 or 2 are rolled into a spiral and inserted into an elastic sleeve 3, the latter serving as a spring element to ensure adequate contact pressure (0.2 $kg/cm^2$). The rolled spiral with spring

elements is inserted into outer housing 4. In some embodiments, the swelling separator and outer housing may also serve as the spring elements.

Figure 4 illustrates a connection 3 between cells 1 and 2 with the cells connected serially or in parallel. Some electrode bags which are meant to be connected can be made from a single piece of conductive fabric. In such a case, all conventional connecting parts are excluded, decreasing accumulator weight and complexity and increasing reliability.

Figure 5 illustrates a one piece multi-electrode design which consists of a special fiber combination with a trim conductivity and insulation fiber or group of fibers, for use as electrode insulation or connecting elements. This trim may be different for weft and warp, for different accumulator designs, or because of weave problems.

The one-piece multi-electrode design includes a conductive part of electrode 1 made from conductive fibers and an insulative part 2 made of insulative fibers. Conductive parts of fabrics may also be used in conjunction with cross conductive thread stripes, which can connect electrode parts.

For a better connection between electrode parts and the connection strip, the connection may be preliminarily plated and welded.

The trim of conductive parts does not determine what kind of electrode (cathode or anode) may be connected and what type of connection, parallel or series, should be used.

These parameters may be chosen as in common battery designs, where a one piece multi-electrode fabric is a common element that permits different designs and electrical configurations of accumulators, fuel cells, or electrolyzers.

The fabric can be coated on one side with PVC, polyethylene, polypropylene or polyurethane, for welding with other layers of the design, and outer shell formation. In such a case, the conductive fibers must be first treated to permit adhesion to the coating material.

Figure 6 illustrates a design that can be realized with a multi-electrode one piece fabric. This design is an example of a slurry electrode accumulator with serial connection of separate cells. The design consists of two one-piece multi-electrode units 1, separated by an electrolyte permeable fabric 2 that can be sewn or welded separately from the electrode design piece.

The welding seams position is in a form that provides insulation of separate cells formation with intake and outlet channels if a flow electrolyte system is used and permeability of outer space.

**EXAMPLES**

Example #1

| | |
|---|---|
| Battery layout | Flat |
| Battery active material | Silver - Zinc |
| Number of cells in battery | 2 |
| Battery voltage | 3 volt |
| Battery capacity | 5 Ah |
| Battery housing thickness | 5.4 mm |
| Battery housing area | 18.5 $cm^2$ |
| Electrode particle diameter | 0.005-0.01mm |

| | |
|---|---|
| Silver electrode thickness | 0.8 mm |
| Zinc electrode thickness | 0.92 mm |
| Silver weight | 19.45g |
| Zinc weight | 11.78g |
| Weight of total active material | 31.23g |
| Weight of conductive material | 1.90g |
| Weight of insulation material | 1.64g |
| Weight of electrolyte, KOH | 21.4g |
| Weight of accessories | 37.1g |
| Total weight of battery | 88.77g |

Example #2

| | |
|---|---|
| Battery layout | Flat |
| Active material | Silver - Zinc |
| Number of cells per battery | 16 |
| Battery voltage | 24 volt |
| Battery capacity | 100 Ah |
| Battery housing thickness | 200mm |
| Battery housing area | 200 $cm^2$ |
| Electrode particle diameter | 0.005-0.01 mm |
| Silver electrode thickness | 0.8 mm |
| Zinc electrode thickness | 0.92 mm |
| Silver weight | 3169g |
| Zinc oxide weight | 2023g |

| | |
|---|---|
| Weight of total active material | 5192g |
| Weight of conductive material | 93.5g |
| Weight of insulation material | 215g |
| Weight of electrolyte, KOH | 2545 g |
| Weight of accessories | 765g |
| Total weight of battery | 8810 g |

Example #3

| | |
|---|---|
| Battery layout | Flat |
| Battery active material | Lead |
| Number of cells in battery | 6 |
| Battery voltage | 12 volt |
| Battery capacity | 60 Ah |
| Battery housing thickness | 150 mm |
| Battery housing area | 120cm$^2$ |
| Electrode particle diameter | 0.005-0.01mm |
| Anode thickness | 0.8 mm |
| Cathode thickness | 0.92 mm |
| Lead weight | 6,300g |
| Lead oxide weight | 7,100g |
| Weight of total active material | 13,400g |
| Weight of conductive material | 421g |
| Weight of insulation material | 85g |
| Weight of electrolyte, acid | 1110g |

| | |
|---|---|
| Weight of accessories | 521g |
| Total weight of battery | 15,452g |

Example #4

| | |
|---|---|
| Battery layout | Spiral |
| Battery active material design | Silver - Zinc |
| Number of cells in battery | 1 |
| Battery voltage | 1.5-1.8 volt |
| Battery capacity | 15 Ah |
| Battery spiral diameter | 30mm |
| Battery spiral height | 27mm |
| Electrode particle diameter | 0.01 mm |
| Silver electrode thickness | 0.8 mm |
| Zinc electrode thickness | 0.92 mm |
| Silver weight | 45.32g |
| Zinc weight | 11.78g |
| Weight of total active material | 57.1 g |
| Weight of conductive material | 1.90g |
| Weight of insulation material | 1.64g |
| Weight of electrolyte, KOH | 28.9g |
| Weight of accessories | 19.5g |
| Total weight of battery | 109.04g |

## What is Claimed is:

1. A rechargeable electrochemical battery cell comprising a closed housing in which there are positioned two or more units which differ only in the active material, each such unit comprising a flat flexible bag of an ion conductive insulating material (membrane) containing a flat, conductive flexible frame of electrode and from both its sides a powder form active material, an electrolyte, where each electrode is connected with a conductor leading to the outside for current uptake, means being provided for maintaining pressure from granule to granule and from granule to electrode flexible frame for needed electrical contact.

2. A cell according to claim 1, which for decreasing dendrite hazards has a conductor executed in the first form of a flexible electrically conducting envelope which contains a flexible conductive support of active material in powder or granular form,

the second electrode being also in the form of a flexible electrically conductive envelope containing an electrically conductive support on which there is a layer of an electrochemically complementary active material, flexible ion-conductive membrane sheet positioned between the two envelopes, and means for exerting pressure on the assembly of electrode separator sheet or membrane/counterelectrode so as to maintain these in close contact with each other, said assembly being immersed in a suitable electrolyte, electrode connections being provided from each of the envelopes.

3. A cell according to claim 1 or 2, where the electrode fabric is woven and pleated active materials is a flexible electrically conducting fabric mainly of carbon fibers and other active material fibers.

4. A cell according to any of claims 1 to 3, where the active material pair is one of the following: Ni/Cd, Ag/Zn, Pb/PbO.

5. A cell according to any of claims 1 to 4, where the support is a flexible fabric comprising a sequence of adjacent parallel conductive and insulating stripes.

6. A cell according to any of claims 1 to 5, where the thickness of each electrode is between about 1 and 10mm.

7. A cell according to any of claims 1 to 6, where the particles of the active material are of a grain size of between about 1 and 10 microns, in a 0.5 to 3mm thick layer with or without a suitable matrix.

8. A cell according to any of claims 1 to 7, where the thickness of the fabric is between about 10 and 100 microns.

9. An electrochemical cell according to any of claims 1 to 8, where the cell is wound in a helical configuration with an external or internal spring applying a pressure on the assembly.

10. An electrochemical cell according to any of claims 1 to 9, having high mechanical strength comprising a high-strength, porous, micron pore size fabric separator.

11. A modified cell according to claim 1, being a fuel cell, where catalytically active material is supported by a ceramic substrate, the reaction being an interaction of oxygen and hydrogen producing water and energy.

12. A fuel cell according to claim 11, where a catalyst is plated on a conductive fabric with high surface area.

13. A cell according to any of claims 1 to 12, where the electrode comprises parallel fibers of carbon and fibers of active material, such as carbon and silver.

14. A cell according to any of claims 1 to 13, where the active material in discharged position is preliminarily pressed under medium pressure to achieve a porosity of 50-60% for the cathode and 30%-50% for the anode in the bulk condition, and where said active material is pressed under flexible low pressure when said cell is fully assembled.

15. A cell according to claim 14 where the preliminary pressure used is about 100 to 200 $kg/cm^2$ and where the low pressure used is about 0.2 to 5 $kg/cm^2$.

16. A cell according to any of claims 1 to 15, where the electrode's flexible conductive support (substrate) or separator positioned in the bulk active material is made from a flexible thin grid material, where said grid material is of the expanded metal type.

17. A cell according to claim 16, where the material of the grid is suitable for anodes made of cadmium, zinc, tin or indium and/or cathodes of nickel or silver.

18 A cell according to any of claims 1 to 17, where the electrode's flexible conductive support positioned in the active material is made of woven graphite fibers, said fibers coated with metal to suppress gas evolution.

19. A cell according to claim 18 wherein the thickness of the metal coating applied to suppress gas evolution is 5 to 15 microns.

20. A cell according to claim 18, wherein the cell is a silver-zinc rechargeable cell and where the metal coating used is nickel or silver for the cathode and tin, indium, cadmium, lead, or zinc for the anode.

21. A cell according to claim 18, where the coating consists of two layers, a solid protective layer of 95-99% solidity and a second layer of 30-60% porosity.

22 A cell according to any of claims 1 to 21 wherein the means for exerting pressure is the outer container of the cell, said container having an elasticity needed to maintain a pressure adequate to ensure electrical contact within the assembled cell.

23. A cell according to any of claims 1 to 22, wherein the cell is a spiral type cell and wherein the means for exerting pressure is executed by a central flexible rod or separator layer.

24. A cell according to any of claims 1 to 23, wherein the separator consists of three layers, the first layer imparting mechanical strength to the separator and providing first stage protection from silver oxide penetration, this layer made from a nylon, polypropylene or polyethylene treated woven fabric, a second layer preventing whisker and silver penetration and made from cellulose materials which increase in volume in electrolyte and produce a constant pressure and electrical contact between the electrode and active materials, and a third layer made of an ion separation polyethylene – polypropylene film and executed in the form of a closed bag.

25. A cell according to any of claims 1 to 24, wherein one of the electrodes has a semi-rigid consistency, said semi-rigid consistency having a porosity of 30-50 %, and said electrode executed by sintering, pressing or other method.

26. A cell according to claim 25, wherein the cell is a secondary silver-zinc cell and wherein the electrode formed as in claim 25 is the silver electrode.

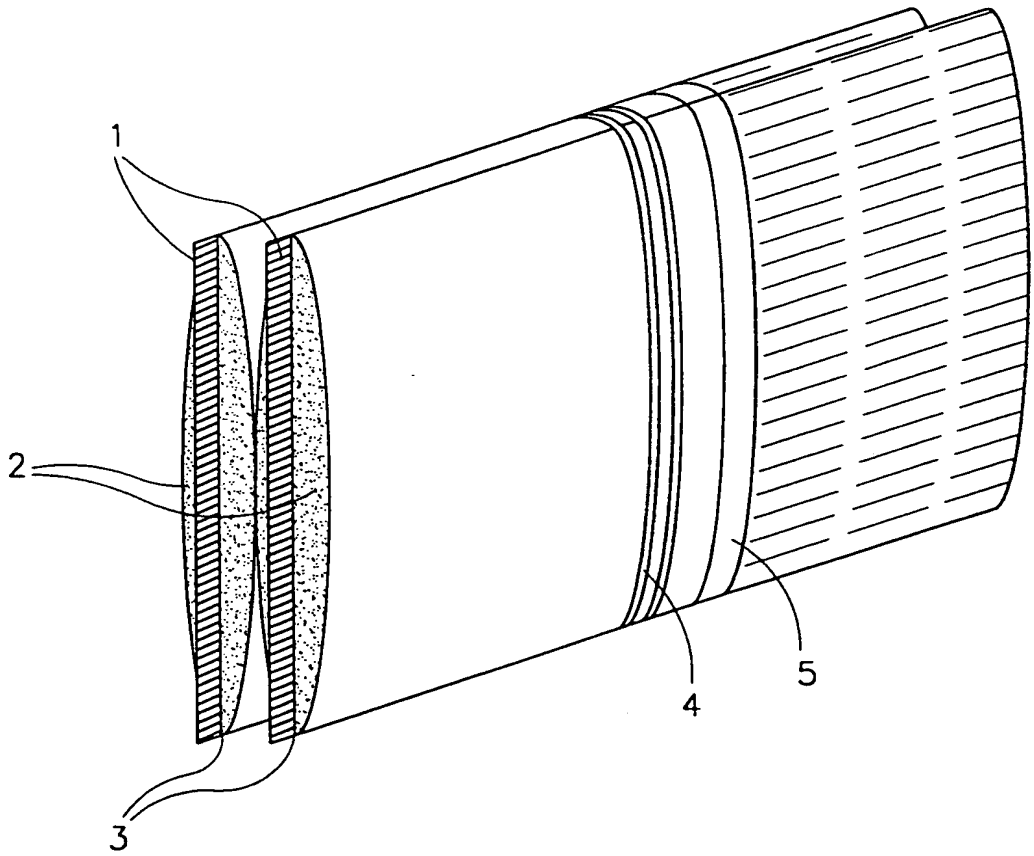
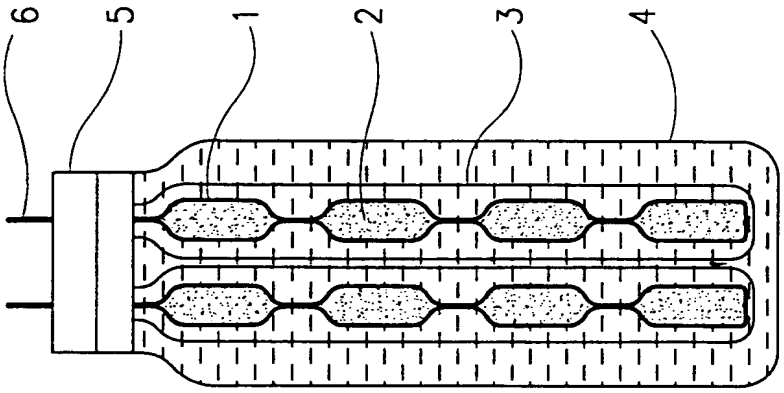



FIG.1



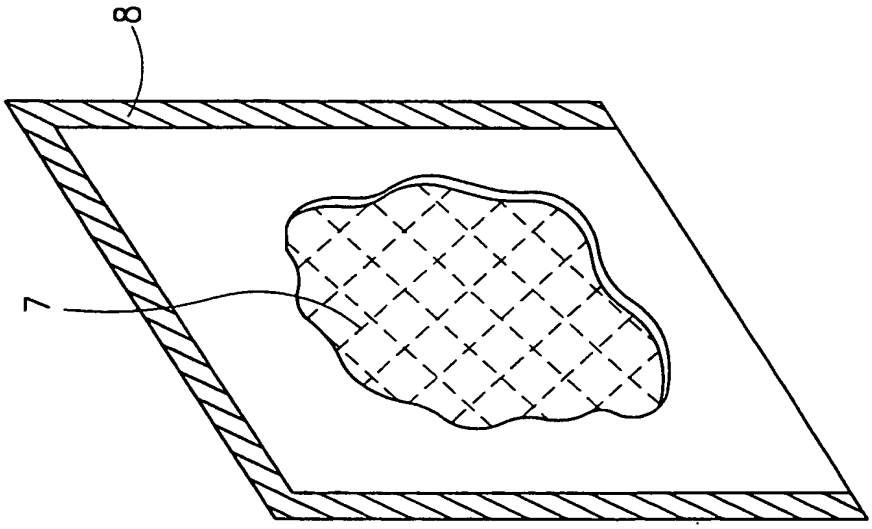




FIG.2

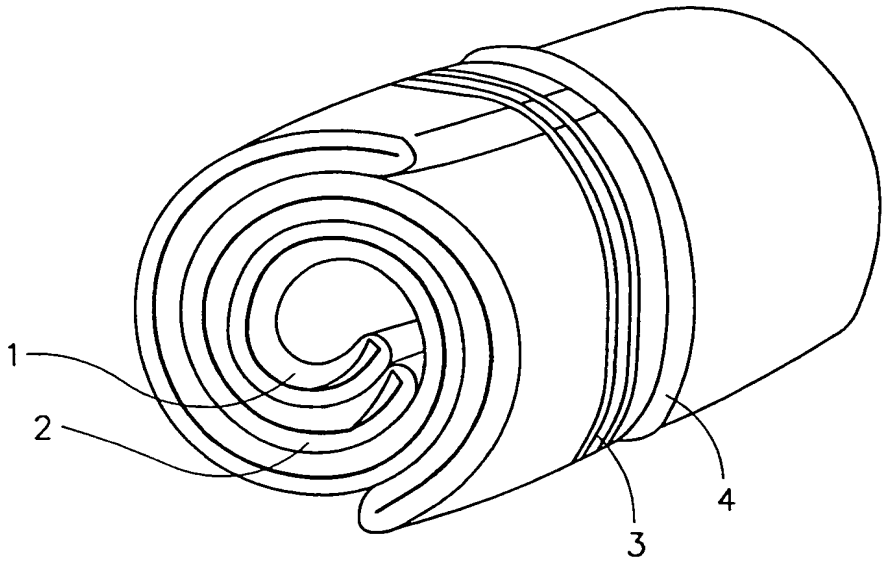



FIG.3

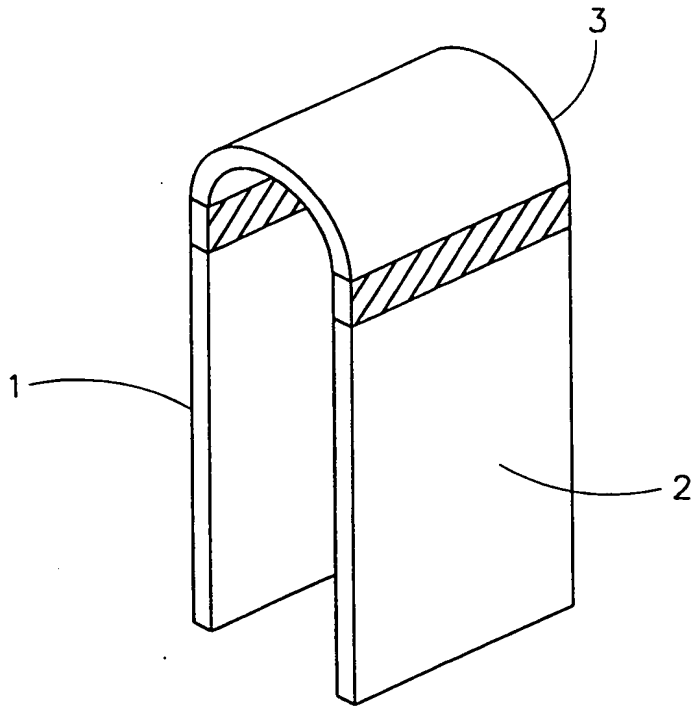



FIG.4

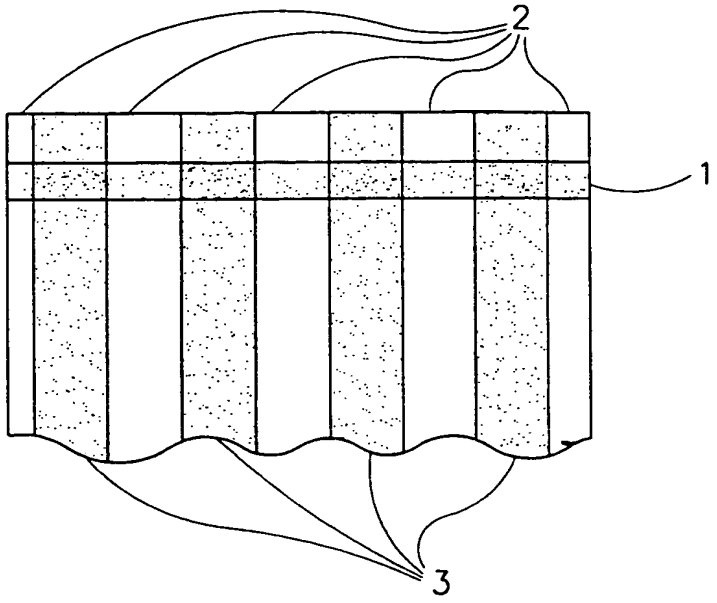



FIG.5

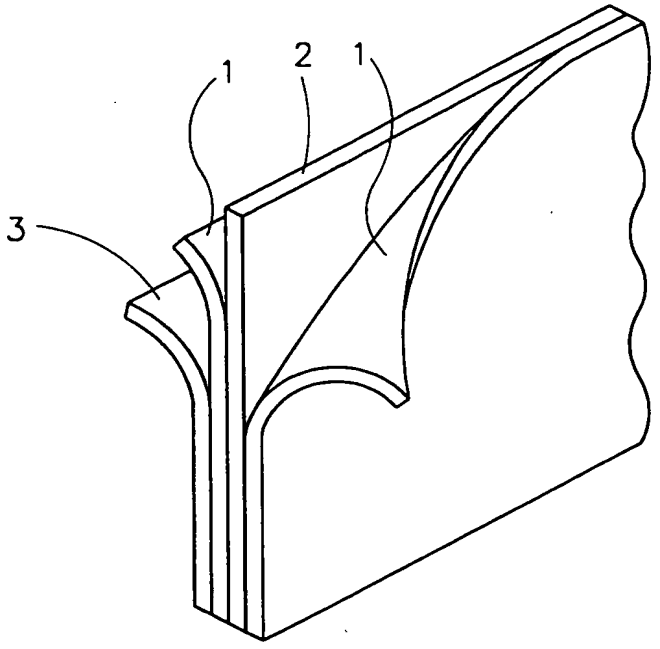



FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL00/00528

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H01M 2/02, 8/04
US CL : 429/129, 131, 132, 136, 139

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 429/129, 131, 132, 136, 139

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 5,580,676 A (HONDA et al.) 03 December 1996, Fig. 20; col. 2, lines 28-35; col. 4, lines 4-6. | 1, 2, 6, 10, 22, 25 |
| X | US 5,480,742 A (EREZ et al.) 02 January 1996, Fig. 4 and col. 3, lines 31-42. | 1, 2, 4, 10, 22 |
| X | US 4,160,068 A (KUMMER) 03 July 1979, col. 3, lines 4-24; column 4, lines 10-14; Figs. 1 and 2. | 1, 2, 4, 10, 22 |
| A | US 829,643 A (FORD) 28 August 1906, the entire document. | 1-26 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

| | | | |
|---|---|---|---|
| * | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A" | document defining the general state of the art which is not considered to be of particular relevance | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "E" | earlier document published on or after the international filing date | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" | document member of the same patent family |
| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | | |

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 14 JANUARY 2001 | 05 FEB 2001 |
| Name and mailing address of the ISA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. (703) 305-3230 | Authorized officer<br>CAROL CHANEY<br>Telephone No. (703) 308-0651 |

Form PCT/ISA/210 (second sheet) (July 1998) ★